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PATENT ABSTRACTS OF JAPAN

(11) Publication number: **09094954 A**

(43) Date of publication of application: **08.04.97**

(51) Int. Cl.	<b>B41J 2/045</b> <b>B41J 2/055</b> <b>B41J 2/16</b>
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(22) Date of filing: <b>28.09.95</b>	(72) Inventor: <b>TAKAHASHI TOMOAKI</b>

(54) **INK JET RECORDING APPARATUS**

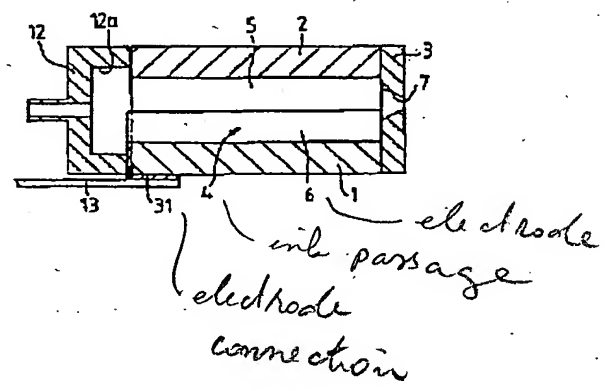
(57) Abstract:

**PROBLEM TO BE SOLVED:** To achieve the miniaturization, wt. reduction and cost reduction of an ink jet recording apparatus using a passage substrate composed of a piezoelectric material.

**SOLUTION:** An electrode 6 is formed to the lower half part of the side surface of the passage partition wall 5 of a passage substrate 11 composed of a piezoelectric material and having ink passages 4 formed thereto. The electrode connection part 31 drawn out to the bottom surface of the passage substrate 1 from the electrode 6 through the end surface of the passage substrate is formed to the passage substrate 1. A cover plate 2, a nozzle plate 3 and an ink supply manifold 12 are bonded to the passage substrate 1. A voltage supply cable 13 is connected to the electrode connection part 31 provided to the bottom surface of the passage substrate. Since an electrical connection part or a common ink chamber 12a is not positioned on the surface (upper surface) of the passage substrate but not positioned on the bottom surface thereof, the miniaturization and wt. reduction of an ink jet recording apparatus can be achieved and

the cost reduction thereof is achieved by the reduction of the use amt. of the piezoelectric material.

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【0014】次に、共通インク室12aを内部に持つインク供給用マニフールド12を洗頭後方端面に接合する。最後に前配電極に外部配電回路（図示せず）から電圧波形を供給するための配線がなされたPFCまたは

【0020】図7に第3の実施例を流路後方より見た背

[0024] 図1~14に第1の実施例を示している。電極6は、インク液滴4内4つの放筋基板1上面を呈し、出される。放筋基板1の表面積(放筋形成面と反対側の面)に $\frac{1}{2}$ より大なりである。正電極6は、放筋基板1上に、電極6aを底面に含む全面に形成する。図3(a)に示したような、レーザ光9aを放筋基板放筋面に斜めに照射し、放筋距離6a、放筋幅6aをマスクとして用いることにより放筋面の電極6aを露わらず全部分だけ除去し、下半分に電極6aを残す。また、放筋距離6aとは反対側の放筋後方2面に、放筋底面とは、リン酸塩ガラスマスク32により必要



manf. of fig 1 & 2  
 manf. of fig 6  
 2nd and 3rd passage substrate

(8)

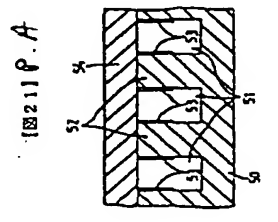
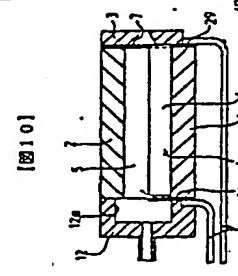
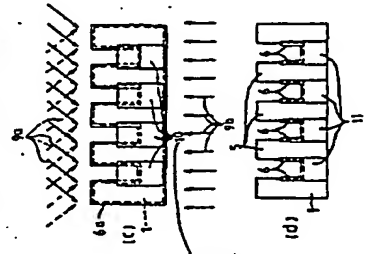
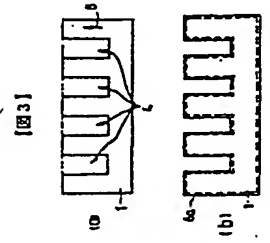
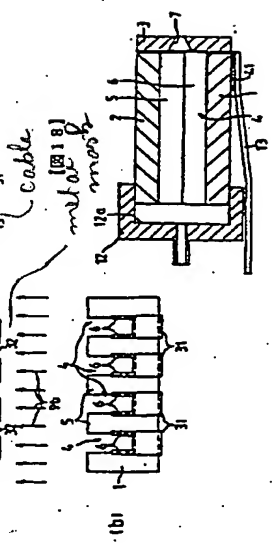
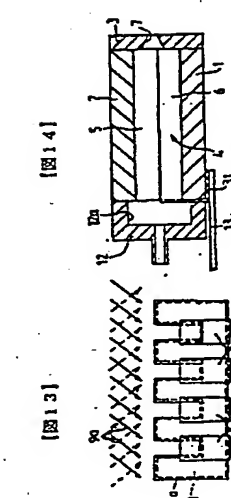
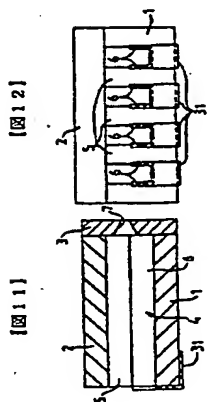
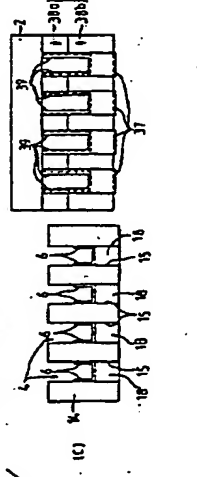
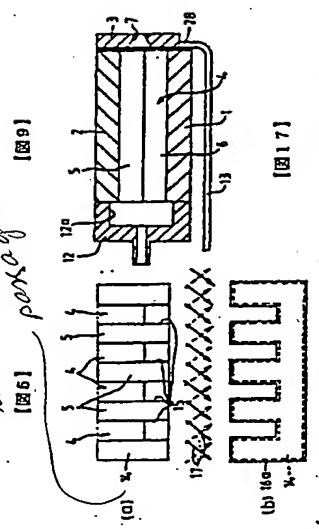
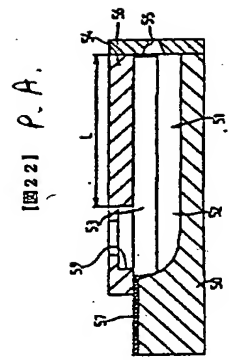
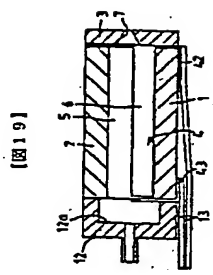
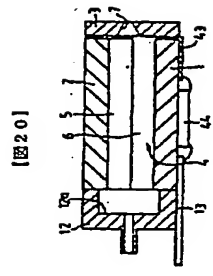
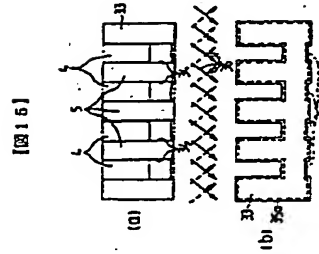
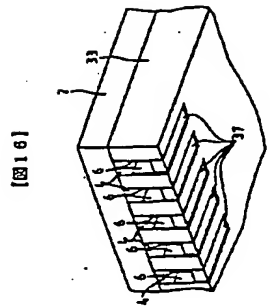


FIG. 22] P. A.

FIG. 21] P. A.

FIG. 12]

FIG. 11]

FIG. 14]

FIG. 13]

FIG. 17]

FIG. 16]

FIG. 17]

FIG. 16]

FIG. 19]

FIG. 20]

FIG. 16]

FIG. 22] P. A.

FIG. 21] P. A.

FIG. 12]

FIG. 11]

FIG. 14]

FIG. 13]

FIG. 17]

FIG. 16]

FIG. 17]

FIG. 16]

FIG. 19]

FIG. 20]

FIG. 16]

FIG. 22] P. A.

FIG. 21] P. A.

FIG. 12]

FIG. 11]

FIG. 14]

FIG. 13]

FIG. 17]

FIG. 16]

FIG. 17]

FIG. 16]

FIG. 19]

FIG. 20]

FIG. 16]

FIG. 22] P. A.

FIG. 21] P. A.

FIG. 12]

FIG. 11]

FIG. 14]

FIG. 13]

FIG. 17]

FIG. 16]

FIG. 17]

FIG. 16]

FIG. 19]

FIG. 20]

FIG. 16]

FIG. 22] P. A.

FIG. 21] P. A.

FIG. 12]

FIG. 11]

FIG. 14]

FIG. 13]

FIG. 17]

FIG. 16]

FIG. 17]

FIG. 16]

FIG. 19]

FIG. 20]

\* NOTICES \*

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## CLAIMS

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[Claim(s)]

[Claim 1] The ink-jet recording device characterized by providing the following. The passage substrate in which two or more electrodes are prepared corresponding to each above-mentioned ink passage while at least a part consists of piezoelectric material and the ink passage of the shape of two or more slot is engraved. The cover plate which has fixed to the above-mentioned ink passage forming face of the above-mentioned passage substrate. The nozzle plate which has fixed to the end side of the above-mentioned passage substrate, and has the opening edge of each above-mentioned ink passage, and two or more nozzles which are open for free passage, respectively. The electrode connection which extends from each above-mentioned electrode, and is crooked, and is pulled out by the end face of the above-mentioned passage substrate.

[Claim 2] The above-mentioned electrode connection is an ink-jet recording device according to claim 1 characterized by extending further, and being crooked and being pulled out by even the base of the above-mentioned passage substrate after extending from each above-mentioned electrode, and being crooked and being pulled out by the end face of the above-mentioned passage substrate.

[Claim 3] The ink-jet recording device according to claim 2 characterized by preparing the drive circuit element connected with the above-mentioned electrode connection in the above-mentioned base.

[Claim 4] The above-mentioned electrode connection is an ink-jet recording device according to claim 1 to 3 characterized by forming a metal membrane in the vadium formed in the above-mentioned end face or the above-mentioned base.

[Claim 5] The ink-jet recording device according to claim 1 to 4 characterized by having fixed the manifold which has the common ink room which supplies ink to each above-mentioned ink passage in either of the end faces of the above-mentioned passage substrate.

[Claim 6] Two or more above-mentioned electrode connections are ink-jet recording devices according to claim 1 to 5 characterized by being formed in an one end-face [ of the above-mentioned passage substrate ], and other-end side side by turns.

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[Translation done.]

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## DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Field of the Invention] this invention relates to the ink-jet recording device which records by the regurgitation of an ink drop.

[0002]

[Description of the Prior Art] Conventionally, the ink-jet recording device which forms ink passage in the piezoelectric material itself is indicated by JP,2-150355,A etc. The cross section of a direction which was along ink passage at drawing 21 about the cross section of a direction perpendicular to the passage of such an ink-jet recording device is shown in drawing 22. This recording device engraves the ink passage 51 of the shape of two or more slot on the passage substrate 50 which consists of piezoelectric material by which polarization was carried out in the thickness direction by cutting etc. After forming an electrode 53 in the both-sides side of the passage septum 52 which has divided the ink passage of these plurality, By joining a cover plate 54 to this passage substrate upper surface, and joining the nozzle plate 56 in which the nozzle 55 for carrying out the regurgitation of the ink drop was formed to the passage outlet end face of the passage substrate 50, each nozzle 55 is made to open each ink passage 51 for free passage, respectively, and it is constituted. An electrode 53 is pulled out even behind [ that the ink passage 51 on the passage substrate 50 was formed / passage ] a field, serves as the electrode connection 57, and is electrically connected with the external electrical circuit (not shown) there. If driver voltage is supplied to this electrode 53, electric field with the direction 58 of polarization perpendicular in the passage septum 52 will occur, the passage septum 52 bends in shearing mode toward the passage 51 inside, the ink in passage is pressurized, and the regurgitation of ink is performed from a nozzle 55. Moreover, the ink of a part consumed by the regurgitation is supplied through the common ink room 59 established in the aforementioned cover plate 54 (or passage substrate 50).

[0003] since the passage substrate itself serves as a pressure generating means using the passage substrate which these ink-jet recording devices become from piezoelectric material -- a pressure source -- others -- it is not necessary to prepare -- passage -- and it is alike and excels in the densification of a nozzle

[0004]

[Problem(s) to be Solved by the Invention] However, as for the ink-jet recording device of these former, in addition to the electrode connection 57 with an external electrical circuit being formed on the same field as the passage engraving side of the passage substrate 50, the common ink room 59 is formed in the cover plate 54 or the passage substrate 50. That is, passage 51 the very thing is formed from the end side of the passage substrate 50 to pars intermedia, but the electrode connection 57 and the common ink room 59 exist in the back. Therefore, the length of a cover plate 54 is very big at the passage substrate 50 row, and it had become the hindrance of a miniaturization and lightweight-izing from the length of the ink passage (pressurization section) 51 required to inject an ink drop originally. If it explains concretely using drawing 22, the overall length of the passage substrate containing the common ink room 59 and the electrode connection 57 is 15-25mm to the ink passage (pressurization section) used in order to carry out the regurgitation of the ink drop being the portion shown by L all over drawing from the nozzle side edge side to the common ink room 59, and usually serving as a length of about L= 2-10mm. Thus, in the conventional ink-jet recording device, it was difficult to shorten the length of the direction of passage, and it had become small and the hindrance of lightweight-izing. Moreover, in the material which constitutes the ink-jet recording device principal part, piezoelectric material was the most expensive, and by the conventional method, since there was much amount of the piezoelectric material used, it caused cost quantity. Moreover, conventionally, with composition, in addition to the ink passage (pressurization section) 51, also in the common ink room 59 and the electrode connection 57, electric capacity was formed by inter-electrode, and the consumed electric current and power were increasing more than required.

[0005] this invention solves the above-mentioned technical problem, and aims at achievement of low-cost[ a miniaturization, lightweight-izing, and ]-izing and low-power-izing in the ink-jet recording device from which the passage substrate itself serves as a pressure generating means using the passage substrate which at least a part becomes from piezoelectric material.

[0006]

[The means for solving invention] The passage substrate in which two or more electrodes are prepared corresponding to each ink passage while at least a part consists of piezoelectric material and the ink passage of the shape of two or more slot is engraved in this invention, in order to attain the above-mentioned purpose, The cover plate which has fixed to the ink passage forming face of a passage substrate, and the nozzle plate which has two or more nozzles which have fixed to the end side of a passage substrate and are open for free passage with the opening edge of each ink passage, respectively, It is characterized by having the electrode



connection which extends from each electrode, and is crooked and is pulled out by the end face of a passage substrate. In addition, after extending an electrode connection from each electrode, and crooking it and being pulled out by the end face of a passage substrate, it is extended further, and is crooked and may be pulled out by even the base of a passage substrate. In this case, the drive circuit element connected with an electrode connection can also be prepared in a base. An electrode connection can do manufacture easily, if a metal membrane is formed in the vadium formed in the end face or the base. Preferably, in either of the end faces of a passage substrate, the manifold which has the common ink room which supplies ink to each ink passage fixes. Two or more electrode connections can also be formed in an one end-face [ of a passage substrate ], and other-end side side by turns. [0007]

[Embodiments of the Invention] Hereafter, the detail of this invention is explained along with an accompanying drawing. The cross section with which drawing 1 met in the direction of passage of the 1st example of this invention, and drawing 2 are the rear view which looked at the 1st example of this invention from passage back.

[0008] The principal part of the ink-jet recording device by this invention is constituted by the passage substrate 1 which consists of piezoelectric material, the cover plate 2 joined to the passage substrate upper surface, and the nozzle plate 3 joined by the end side of the passage substrate 1. The ink passage 4 of the shape of two or more slot is engraved on the passage substrate 1 upper surface by cutting etc., and opening of this ink passage 4 is carried out to the end face of the passage substrate 1. The electrode 6 is formed in the both-sides-side of the passage septum 5 which has divided the ink passage 4. Moreover, the nozzle plate 3 is fixed to the end face of the passage substrate 1, and the \*\* nozzle 7 which is open for free passage to each ink passage 4, and breathes out an ink drop to this nozzle plate 3 is formed. The length of the direction of passage of the passage substrate 1 and a cover plate 2 is substantially constituted equally with length L of the ink passage 4 which is the portion which applies a pressure to ink. Moreover, an electrode 6 is formed covering ink passage 4 overall length, and is further formed also in passage substrate 1 end face (setting to this example, a nozzle plate 3 is the passage back end face of an opposite side) located right-angled with this ink passage 4 continuously.

[0009] Next, the manufacture method of the passage substrate 1 used for the ink-jet recording device of this 1st example is explained using drawing 3. In addition, drawing 3 is process drawing explaining the manufacture method of the passage substrate 1 used for the 1st example, and serves as front view of a passage substrate back end face. First, as shown in drawing 3 (a), the ink passage 4 of two or more shape of a in general parallel slot is formed in the substrate 1 by which consists of piezoelectric material, such as PZT, and polarization is carried out in the thickness direction as the 1st process by machine cutting, such as a dicing saw. For the passage substrate 1, the passage depth is [ the thickness of the septum 5 which divides 50 micrometers - 200 micrometers and passage of 200 micrometers - 1mm and the depth ] 50 micrometers - 200 micrometers by length of 2mm - 10mm, and the thickness of about 0.5-2mm.

[0010] The 2nd process forms electrode layer 6a in the passage substrate 1 into which passage was processed as shown in drawing 3 (b) all over including the inside of passage 4 by the spatter or electroless deposition. An electrode material is formed by the thickness of 0.1 micrometers - 3 micrometers by aluminum, nickel, Cr, Au, etc. The 3rd process is separation formation of an electrode 6. In this example, polarization of the piezoelectric passage substrate 1 is carried out in the substrate thickness direction, by impressing electric field perpendicular to the direction 8 of polarization to the passage septum 5, a septum 5 deforms toward the ink passage 4 inside in shearing mode, and an ink drop is breathed out from a nozzle 7. in order to perform this ink \*\*\*\* efficiently -- an electrode 6 -- the height direction of the passage septum 5, as it needs to be formed in general to the half and shown in drawing 3 (c). Laser beam 9a by excimer lasers, such as an YAG laser, and F2, ArF, KrF, XeCl, XeF, is irradiated aslant in a passage substrate 1 passage side. By using passage septum 5 the very thing as a mask, only an upper half can remove electrode layer 6a of a passage side in general, and the electrode 6 of a desired configuration can be obtained in the lower half.

[0011] Moreover, in a nozzle plate 3, the passage back end face of an opposite side irradiates the aforementioned laser beam 9b, after protecting the required section with the metal masks 10, such as phosphor bronze, and it carries out separation formation of the electrode connection 11 for supplying power from an external electrical circuit (not shown) as shown in drawing 3 (d). Thus, the passage substrate 1 in which a desired electrode 6 and the desired electrode connection 11 were formed can be obtained. In addition, complete irradiation of the aforementioned laser or mechanical polish removes electrode layer 6a prepared in the nozzle side edge side of the passage substrate 1, the ends side parallel to passage 4, and the base.

[0012] Thus, the cover plate 2 with a thickness of about 0.2-2mm is joined to the created passage substrate 1 for example, with epoxy system adhesives by PZT, ceramics, glass, plastics, etc.

[0013] Next, process it by laser radiation, and form, or join the nozzle plate 3 which was made from the polyimide film and was formed by electrocasting or the micro press method by being made from a metal to passage substrate 1 end face, each ink passage 4 is made to open each nozzle 7 for free passage, and the principal part of the ink-jet recording device of this example shown in drawing 1 is completed.

[0014] Next, the manifold 12 for ink supply which has common ink room 12a in the interior is joined to a passage back end face. The cables 13, such as FPC by which the wiring for finally supplying a voltage waveform to the aforementioned electrode from an external electrical circuit (not shown) was made, or heat sealing, are connected to the aforementioned electrode connection 11 in which it was prepared by the end face of the passage substrate 1, and the ink-jet recording device of this example shown in drawing 4 is completed.

[0015] the length of the passage substrate 1 which had become 15mm - 25mm and a big thing by the conventional method according to this example -- the length of the ink passage 4 -- substantial -- etc. -- carrying out -- it is -- 2mm - 10mm -- large -- small -- it can carry out -- an ink-jet recording device -- below the conventional half -- small ---izing can be carried out



lightweight ] Moreover, although the piezoelectric material which forms the passage substrate 1 is the most expensive in raw material, by having miniaturized, a material cost is halved and an ink-jet recording device can be low-cost-ized. Moreover, addition capacity other than the ink passage section can decrease and low-power-ize by having miniaturized.

[0016] The perspective diagram of the passage back section of the principal part of the 2nd example is shown for process drawing which explains to drawing 5 the manufacture method of the passage substrate 14 used for the ink-jet recording device which is the 2nd example of this invention in drawing 6. The manufacture method of the passage substrate 14 used for the ink-jet recording device of the 2nd example is explained using drawing 5 seen from the passage back end face. In addition, the thing without publications, such as a material name and a size, is the same as the 1st example. The 1st process forms the ink passage 4 of two or more shape of a in general parallel slot in the piezoelectric passage substrate 14 by machine cutting, such as a dicing saw, as shown in drawing 5 (a). Next, \*\*\*\* 15 which stood in a row in each passage 4 in the field in which passage 4 was formed, and the end face which makes a right angle is machined. Although the depth of \*\*\*\* 15 is 3 micrometers or more of the thickness maximum of an electrode as a requirement, in consideration of machining precision, its 5 micrometers or more are desirable. Moreover, if too not much deep, in order to cause trouble to electrical installation with a cable 13, it is desirable to be referred to as 30 micrometers or less. It is almost the same as the passage section, for example, the width of face of \*\*\*\* 15 is 50 micrometers - 200 micrometers.

[0017] The 2nd process forms electrode layer 16a in the whole surface by the spatter or electroless deposition at the piezoelectric passage substrate 14 into which passage 4 was processed as shown in drawing 5 (b). And the 3rd process is separation formation of an electrode 16. The laser beams 17, such as excimer lasers, such as an YAG laser, and F2, ArF, KrF, XeCl, XeF, are irradiated aslant in a passage substrate passage side, and only an upper half can remove electrode layer 16a of a passage side in general by using passage septum 5 the very thing as a mask.

[0018] Moreover, if the end face of passage back is ground to the grade whose \*\*\*\* 15 is not lost by the mechanical method, only the electrode layer in \*\*\*\* 15 will remain, and as shown in drawing 5 (c), separation formation of the electrode connection 18 for supplying power to a passage end face from an external electrical circuit will be carried out.

[0019] According to this example, the metal mask for forming an electrode pattern in a passage back end face which was used in the 1st example becomes unnecessary, and can simplify a manufacturing process.

[0020] The rear view which looked at the 3rd example from passage back to drawing 7 is shown. In the 3rd example, since the passage substrate 20 which made two piezoelectric substrates 20a and 20b from which the direction 19 of polarization differed rival is used and the deformation direction by the shearing mode of the upper and lower sides of a passage septum becomes the same, it becomes unnecessary only for a half to remove an electrode 21, and a manufacturing process can be facilitated further.

[0021] The rear view which looked at the 4th example from passage back to drawing 8 is shown. In the 4th example, if voltage is impressed between the electrode 24 which heights 23 were formed in the lower part of each passage 4 created by the piezoelectric passage substrate 22, and was prepared in the heights upper surface, and the electrode 25 prepared in the lower part, into heights, electric field parallel to the direction 26 of polarization will occur, heights 23 will deform toward the drawing upper part by the piezo-electric longitudinal mode, a pressure will occur in the ink in ink passage, and an ink drop will be breathed out. The electrode 24 on the upper surface of heights is pulled out by the end face perpendicular to the passage 4 of the passage substrate 22 by the same method as the aforementioned method, and serves as an external electrical circuit and the electrode connection 27 by which electric connection is made by the end face. Thus, this invention is applicable not only in the ink-jet recording device which used shearing mode.

[0022] The cross section which met in the direction of passage of the 5th example at drawing 9 is shown. In the 5th example, an electrode 6 is pulled out by the same end face as the field where the nozzle plate 3 of the passage substrate 1 is joined, and the electrical installation of the electrode connection 28 and a cable 13 is made on the nozzle plate side edge side. By this composition, the flexibility of cable wiring increases and the whole recording device can be miniaturized further. In addition, when the crevice between some is generated between the passage substrate 1 and a nozzle plate 3 in the portion in which the electrode connection 29 does not exist, the seal of the adhesives for nozzle plate 3 adhesion is filled up with and carried out.

[0023] The cross section which met in the direction of passage of the 6th example at drawing 10 is shown. In the 6th example, an electrode 6 is pulled out by turns by the ends side of the end face to which the nozzle plate 3 of the passage substrate 1 is joined, and the end face of an opposite side every other passage, the electrical installation of the electrode connections 29 and 30 and a cable 13 is made on an ends side, and it connects with the external electrical circuit. If a passage pitch is conventionally set to about 100 micrometers or less, by taking this composition, the difficult electrode connection can make the pitch of an electrode connection twice a passage pitch, and can realize a high definition recording device.

[0024] The 7th example is shown in drawing 11 - 14. The electrode 6 is pulled out by even the passage substrate base (a passage forming face and field of an opposite side) through the inside of the ink passage 4, and passage substrate 1 end face. That is, electrode layer 6a is formed in the passage substrate 1 in which it became from piezoelectric material and the ink passage 4 was formed all over including a base. Laser beam 9a as shown in drawing 3 (a) is irradiated aslant in a passage substrate passage side, and by using passage septum 5 the very thing as a mask, only an upper half removes electrode 6a of a passage side in general, and it leaves an electrode 6 to a lower half. Moreover, in a nozzle plate 3, the passage back end face and passage substrate base of an opposite side irradiate laser beam 9b, after protecting the required section with the metal masks 32, such as phosphor bronze, and they form the electrode connection 31 for supplying power from an external electrical circuit as shown in drawing 3 (b). In addition, complete irradiation of the aforementioned laser or mechanical polish removes electrode layer 6a of the nozzle side edge side of a passage substrate, and an ends side parallel to passage.

[0025] A cover plate 2 and a nozzle plate 3 are joined to this passage substrate 1, and the principal part of an ink-jet recording device is completed. And the manifold 12 for ink supply which has common ink room 12a in the interior is joined to a passage back end face. The cable 13 for voltage supply is connected to the last at the aforementioned electrode connection 31 in which it was prepared on the base of a passage substrate, and the ink-jet recording device of this example shown in drawing 14 is completed.

[0026] The 8th example is shown in drawing 15 and 16. The 8th example forms electrode layer 35a in the whole surface, after forming \*\*\*\* 34 which stood in a row in each passage 11 in the position which should form an electrode connection in the field in which the passage of a passage substrate was formed, the end face which makes a right angle, and a base, as shown in drawing 15 (a). And as shown in drawing 15 (b), while irradiating a laser beam 36 and forming an electrode 6 in the passage septum 5 side, the end face in which \*\*\*\* 34 was formed, and a base are ground to the grade whose \*\*\*\* 34 is not lost by the mechanical method. Only the electrode layer in \*\*\*\* 34 remains by this, and as shown in drawing 15 (c), the electrode connection 37 for supplying power to passage substrate 33 base from an external electrical circuit is formed.

[0027] The front view which looked at the 9th example from passage back to drawing 17 is shown. In the 9th example, since the passage substrate 38 which made two piezoelectric substrates 38a and 38b from which the direction of polarization differed rival is used and the deformation direction by the shearing mode of the upper and lower sides of a passage septum becomes the same, it becomes unnecessary only for a half to remove an electrode 39, and a manufacturing process can be facilitated further.

[0028] The cross section which met in the direction of passage of the 10th example at drawing 18 is shown. In the 10th example, an electrode is pulled out to the base of the passage substrate 1 via the same end face as the field where the nozzle plate 3 of the passage substrate 1 is joined, and the electrode connection 41 with an external electrical circuit is made by the nozzle plate side of passage substrate 1 base. Since the manifold 12 and the electrode connection 41 for supplying the ink which had common ink room 12a in the interior which were prepared in passage back are separable with this composition, the reliability of ink sealing of a manifold 12 and the ink-jet recording device principal part can be raised.

[0029] The cross section which met in the direction of passage of the 11th example at drawing 19 is shown. In the 11th example, it is pulled out from each electrode to a part of base [ at least ] of a passage substrate via two end faces of the passage substrate 1 by turns every other passage, and the electrode connections 42 and 43 are formed. And the electrical installation of the electrode connections 42 and 43 and a cable 13 is made on the base of the passage substrate 1. If a passage pitch is conventionally set to about 100 micrometers or less, the difficult electrode connection can make the pitch of an electrode connection twice a passage pitch by taking this composition, electrode connection is possible also for the passage pitch which is about 50 micrometers, and a high definition recording device can be realized.

[0030] The cross section which met in the direction of passage of the 12th example at drawing 20 is shown. In the 12th example, the drive circuit element 44 and the so-called IC are joined to passage substrate 1 base. The output section of the drive circuit element 44 is wire bonding etc., and is electrically connected with the electrode connection 43 pulled out to the base of a passage substrate via the end face of a passage substrate. The control signal and power to a drive circuit element are supplied through a cable 13 from an external electrical circuit (not shown). The number of electric wiring connected with the drive circuit element 44 from an external electrical circuit by carrying out the serial transfer of the data at an ink-jet recording device can be reduced sharply. In this example, it becomes possible to carry the drive circuit element 44, without enlarging the passage substrate 1 and the whole ink-jet recording device, in order to use the passage substrate base which was not used conventionally.

[0031]

[Effect of the Invention] In the ink-jet recording device in which the electrode is formed by this invention corresponding to each ink passage using the passage substrate which at least a part becomes from piezoelectric material as mentioned above Since the electrode connection pulled out from each electrode to the end face or base of a passage substrate is formed Electrical installation with an external drive circuit can be performed on an end face or a base, does not need to provide the space for electrical installation on an ink passage forming face, and can make a passage substrate and a cover plate substantially length of the same grade with ink passage. therefore -- according to this invention -- an ink-jet recording device -- below the conventional half -- small -- lightweight -- since it can do-izing, and a material cost decreases and the amount of the expensive piezoelectric material used becomes less especially by having miniaturized, offer of a cheap ink-jet recording device is attained By furthermore having miniaturized, addition capacity decreases and low-power-ization is attained. Moreover, it is still more effective if it is the composition which fixes the manifold which does not prepare a common ink room for a common ink room on a passage forming face, but has a common ink room to a passage substrate end face. It becomes possible to carry a drive circuit element, without enlarging a form passage substrate and an ink-jet recording device, in preparing an electrode connection in a passage substrate base.

[0032] A manufacturing process will become easy, if a metal membrane is formed in \*\*\*\*\* formed in the passage substrate end face or the base and an electrode connection is constituted. If two or more above-mentioned electrode connections are formed in an one end-face [ of a passage substrate ], and other-end side side by turns, since the pitch of an electrical installation portion will be made to a double size rather than a passage pitch, it contributes to the densification of ink passage.

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[Translation done.]

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PRIOR ART

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[Description of the Prior Art] Conventionally, the ink-jet recording device which forms ink passage in the piezoelectric material itself is indicated by JP,2-150355,A etc. The cross section of a direction which was along ink passage at drawing 21 about the cross section of a direction perpendicular to the passage of such an ink-jet recording device is shown in drawing 22. This recording device engraves the ink passage 51 of the shape of two or more slot on the passage substrate 50 which consists of piezoelectric material by which polarization was carried out in the thickness direction by cutting etc. After forming an electrode 53 in the both-sides side of the passage septum 52 which has divided the ink passage of these plurality, By joining a cover plate 54 to this passage substrate upper surface, and joining the nozzle plate 56 in which the nozzle 55 for carrying out the regurgitation of the ink drop was formed to the passage outlet end face of the passage substrate 50, each nozzle 55 is made to open each ink passage 51 for free passage, respectively, and it is constituted. An electrode 53 is pulled out even behind [ that the ink passage 51 on the passage substrate 50 was formed / passage ] a field, serves as the electrode connection 57, and is electrically connected with the external electrical circuit (not shown) there. If driver voltage is supplied to this electrode 53, electric field with the direction 58 of polarization perpendicular in the passage septum 52 will occur, the passage septum 52 bends in shearing mode toward the passage 51 inside, the ink in passage is pressurized, and the regurgitation of ink is performed from a nozzle 55. Moreover, the ink of a part consumed by the regurgitation is supplied through the common ink room 59 established in the aforementioned cover plate 54 (or passage substrate 50).

[0003] since the passage substrate itself serves as a pressure generating means using the passage substrate which these ink-jet recording devices become from piezoelectric material -- a pressure source -- others -- it is not necessary to prepare -- passage -- and it is alike and excels in the densification of a nozzle

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EFFECT OF THE INVENTION

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[Effect of the Invention] In the ink-jet recording device in which the electrode is formed by this invention corresponding to each ink passage using the passage substrate which at least a part becomes from piezoelectric material as mentioned above. Since the electrode connection pulled out from each electrode to the end face or base of a passage substrate is formed, electrical installation with an external drive circuit can be performed on an end face or a base, does not need to provide the space for electrical installation on an ink passage forming face, and can make a passage substrate and a cover plate substantially length of the same grade with ink passage. therefore -- according to this invention -- an ink-jet recording device -- below the conventional half -- small -- lightweight -- since it can do-izing, and a material cost decreases and the amount of the expensive piezoelectric material used becomes less especially by having miniaturized, offer of a cheap ink-jet recording device is attained. By furthermore having miniaturized, addition capacity decreases and low-power-ization is attained. Moreover, it is still more effective if it is the composition which fixes the manifold which does not prepare a common ink room for a common ink room on a passage forming face, but has a common ink room to a passage substrate end face. It becomes possible to carry a drive circuit element, without enlarging a form passage substrate and an ink-jet recording device, in preparing an electrode connection in a passage substrate base.

[0032] A manufacturing process will become easy, if a metal membrane is formed in the vadum formed in the passage substrate end face or the base and an electrode connection is constituted. If two or more above-mentioned electrode connections are formed in an one end-face [ of a passage substrate ], and other-end side side by turns, since the pitch of an electrical installation portion will be made to a double size rather than a passage pitch, it contributes to the densification of ink passage.

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TECHNICAL PROBLEM

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[Problem(s) to be Solved by the Invention] However, as for the ink-jet recording device of these former, in addition to the electrode connection 57 with an external electrical circuit being formed on the same field as the passage engraving side of the passage substrate 50, the common ink room 59 is formed in the cover plate 54 or the passage substrate 50. That is, passage 51 the very thing is formed from the end side of the passage substrate 50 to pars intermedia, but the electrode connection 57 and the common ink room 59 exist in the back. Therefore, the length of a cover plate 54 is very big at the passage substrate 50 row, and it had become the hindrance of a miniaturization and lightweight-izing from the length of the ink passage (pressurization section) 51 required to inject an ink drop originally. If it explains concretely using drawing 22, the overall length of the passage substrate containing the common ink room 59 and the electrode connection 57 is 15-25mm to the ink passage (pressurization section) used in order to carry out the regurgitation of the ink drop being the portion shown by L all over drawing from the nozzle side edge side to the common ink room 59, and usually serving as a length of about  $L = 2-10\text{mm}$ . Thus, in the conventional ink-jet recording device, it was difficult to shorten the length of the direction of passage, and it had become small and the hindrance of lightweight-izing. Moreover, in the material which constitutes the ink-jet recording device principal part, piezoelectric material was the most expensive, and by the conventional method, since there was much amount of the piezoelectric material used, it caused cost quantity. Moreover, conventionally, with composition, in addition to the ink passage (pressurization section) 51, also in the common ink room 59 and the electrode connection 57, electric capacity was formed by inter-electrode, and the consumed electric current and power were increasing more than required.

[0005] this invention solves the above-mentioned technical problem, and aims at achievement of low-cost[ a miniaturization, lightweight-izing, and ]-izing and low-power-izing in the ink-jet recording device from which the passage substrate itself serves as a pressure generating means using the passage substrate which at least a part becomes from piezoelectric material.

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MEANS

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[The means for solving invention] The passage substrate in which two or more electrodes are prepared corresponding to each ink passage while at least a part consists of piezoelectric material and the ink passage of the shape of two or more slot is engraved in this invention, in order to attain the above-mentioned purpose, The cover plate which has fixed to the ink passage forming face of a passage substrate, and the nozzle plate which has two or more nozzles which have fixed to the end side of a passage substrate and are open for free passage with the opening edge of each ink passage, respectively, It is characterized by having the electrode connection which extends from each electrode, and is crooked and is pulled out by the end face of a passage substrate. In addition, after extending an electrode connection from each electrode, and crooking it and being pulled out by the end face of a passage substrate, it is extended further, and is crooked and may be pulled out by even the base of a passage substrate. In this case, the drive circuit element connected with an electrode connection can also be prepared in a base. An electrode connection can do manufacture easily, if a metal membrane is formed in the vadium formed in the end face or the base. Preferably, in either of the end faces of a passage substrate, the manifold which has the common ink room which supplies ink to each ink passage fixes. Two or more electrode connections can also be formed in an one end-face [ of a passage substrate ], and other-end side side by turns.

[0007]

[Embodiments of the Invention] Hereafter, the detail of this invention is explained along with an accompanying drawing. The cross section with which drawing 1 met in the direction of passage of the 1st example of this invention, and drawing 2 are the rear view which looked at the 1st example of this invention from passage back.

[0008] The principal part of the ink-jet recording device by this invention is constituted by the passage substrate 1 which consists of piezoelectric material, the cover plate 2 joined to the passage substrate upper surface, and the nozzle plate 3 joined by the end side of the passage substrate 1. The ink passage 4 of the shape of two or more slot is engraved on the passage substrate 1 upper surface by cutting etc., and opening of this ink passage 4 is carried out to the end face of the passage substrate 1. The electrode 6 is formed in the both-sides side of the passage septum 5 which has divided the ink passage 4. Moreover, the nozzle plate 3 is fixed to the end face of the passage substrate 1, and the \*\* nozzle 7 which is open for free passage to each ink passage 4, and breathes out an ink drop to this nozzle plate 3 is formed. The length of the direction of passage of the passage substrate 1 and a cover plate 2 is substantially constituted equally with length L of the ink passage 4 which is the portion which applies a pressure to ink. Moreover, an electrode 6 is formed covering ink passage 4 overall length, and is further formed also in passage substrate 1 end face (setting to this example, a nozzle plate 3 is the passage back end face of an opposite side) located right-angled with this ink passage 4 continuously.

[0009] Next, the manufacture method of the passage substrate 1 used for the ink-jet recording device of this 1st example is explained using drawing 3 . In addition, drawing 3 is process drawing explaining the manufacture method of the passage substrate 1 used for the 1st example, and serves as front view of a passage substrate back end face. First, as shown in drawing 3 (a), the ink passage 4 of two or more shape of a in general parallel slot is formed in the substrate 1 by which consists of piezoelectric material, such as PZT, and polarization is carried out in the thickness direction as the 1st process by machine cutting, such as a dicing saw. For the passage substrate 1, the passage depth is [ the thickness of the septum 5 which divides 50 micrometers - 200 micrometers and passage of 200 micrometers - 1mm and the depth ] 50 micrometers - 200 micrometers by length of 2mm - 10mm, and the thickness of about 0.5-2mm.

[0010] The 2nd process forms electrode layer 6a in the passage substrate 1 into which passage was processed as shown in drawing 3 (b) all over including the inside of passage 4 by the spatter or electroless deposition. An electrode material is formed by the thickness of 0.1 micrometers - 3 micrometers by aluminum, nickel, Cr, Au, etc. The 3rd process is separation formation of an electrode 6. In this example, polarization of the piezoelectric passage substrate 1 is carried out in the substrate thickness direction, by impressing electric field perpendicular to the direction 8 of polarization to the passage septum 5, a septum 5 deforms toward the ink passage 4 inside in shearing mode, and an ink drop is breathed out from a nozzle 7. in order to perform this ink \*\*\*\* efficiently -- an electrode 6 -- the height direction of the passage septum 5, as it needs to be formed in general to the half and shown in drawing 3 (c) Laser beam 9a by excimer lasers, such as an YAG laser, and F2, ArF, KrF, XeCl, XeF, is irradiated aslant in a passage substrate 1 passage side. By using passage septum 5 the very thing as a mask, only an upper half can remove electrode layer 6a of a passage side in general, and the electrode 6 of a desired configuration can be obtained in the lower half.

[0011] Moreover, in a nozzle plate 3, the passage back end face of an opposite side irradiates the aforementioned laser beam 9b, after protecting the required section with the metal masks 10, such as phosphor bronze, and it carries out separation formation of the electrode connection 11 for supplying power from an external electrical circuit (not shown) as shown in drawing 3 (d). Thus,

the passage substrate 1 in which a desired electrode 6 and the desired electrode connection 11 were formed can be obtained. In addition, complete irradiation of the aforementioned laser or mechanical polish removes electrode layer 6a prepared in the nozzle side edge side of the passage substrate 1, the ends side parallel to passage 4, and the base.

[0012] Thus, the cover plate 2 with a thickness of about 0.2-2mm is joined to the created passage substrate 1 for example, with epoxy system adhesives by PZT, ceramics, glass, plastics, etc.

[0013] Next, process it by laser radiation, and form, or join the nozzle plate 3 which was made from the polyimide film and was formed by electrocasting or the micro press method by being made from a metal to passage substrate 1 end face, each ink passage 4 is made to open each nozzle 7 for free passage, and the principal part of the ink-jet recording device of this example shown in drawing 1 is completed.

[0014] Next, the manifold 12 for ink supply which has common ink room 12a in the interior is joined to a passage back end face. The cables 13, such as FPC by which the wiring for finally supplying a voltage waveform to the aforementioned electrode from an external electrical circuit (not shown) was made, or heat sealing, are connected to the aforementioned electrode connection 11 in which it was prepared by the end face of the passage substrate 1, and the ink-jet recording device of this example shown in drawing 4 is completed.

[0015] the length of the passage substrate 1 which had become 15mm - 25mm and a big thing by the conventional method according to this example -- the length of the ink passage 4 -- substantial -- etc. -- carrying out -- it is -- 2mm - 10mm -- large -- small -- it can carry out -- an ink-jet recording device -- below the conventional half -- small ---izing can be carried out lightweight ] Moreover, although the piezoelectric material which forms the passage substrate 1 is the most expensive in raw material, by having miniaturized, a material cost is halved and an ink-jet recording device can be low-cost-ized. Moreover, addition capacity other than the ink passage section can decrease and low-power-ize by having miniaturized.

[0016] The perspective diagram of the passage back section of the principal part of the 2nd example is shown for process drawing which explains to drawing 5 the manufacture method of the passage substrate 14 used for the ink-jet recording device which is the 2nd example of this invention in drawing 6. The manufacture method of the passage substrate 14 used for the ink-jet recording device of the 2nd example is explained using drawing 5 seen from the passage back end face. In addition, the thing without publications, such as a material name and a size, is the same as the 1st example. The 1st process forms the ink passage 4 of two or more shape of a in general parallel slot in the piezoelectric passage substrate 14 by machine cutting, such as a dicing saw, as shown in drawing 5 (a). Next, \*\*\*\* 15 which stood in a row in each passage 4 in the field in which passage 4 was formed, and the end face which makes a right angle is machined. Although the depth of \*\*\*\* 15 is 3 micrometers or more of the thickness maximum of an electrode as a requirement, in consideration of machining precision, its 5 micrometers or more are desirable. Moreover, if too not much deep, in order to cause trouble to electrical installation with a cable 13, it is desirable to be referred to as 30 micrometers or less. It is almost the same as the passage section, for example, the width of face of \*\*\*\* 15 is 50 micrometers - 200 micrometers.

[0017] The 2nd process forms electrode layer 16a in the whole surface by the spatter or electroless deposition at the piezoelectric passage substrate 14 into which passage 4 was processed as shown in drawing 5 (b). And the 3rd process is separation formation of an electrode 16. The laser beams 17, such as excimer lasers, such as an YAG laser, and F2, ArF, KrF, XeCl, XeF, are irradiated aslant in a passage substrate passage side, and only an upper half can remove electrode layer 16a of a passage side in general by using passage septum 5 the very thing as a mask.

[0018] Moreover, if the end face of passage back is ground to the grade whose \*\*\*\* 15 is not lost by the mechanical method, only the electrode layer in \*\*\*\* 15 will remain, and as shown in drawing 5 (c), separation formation of the electrode connection 18 for supplying power to a passage end face from an external electrical circuit will be carried out.

[0019] According to this example, the metal mask for forming an electrode pattern in a passage back end face which was used in the 1st example becomes unnecessary, and can simplify a manufacturing process.

[0020] The rear view which looked at the 3rd example from passage back to drawing 7 is shown. In the 3rd example, since the passage substrate 20 which made two piezoelectric substrates 20a and 20b from which the direction 19 of polarization differed rival is used and the deformation direction by the shearing mode of the upper and lower sides of a passage septum becomes the same, it becomes unnecessary only for a half to remove an electrode 21, and a manufacturing process can be facilitated further.

[0021] The rear view which looked at the 4th example from passage back to drawing 8 is shown. In the 4th example, if voltage is impressed between the electrode 24 which heights 23 were formed in the lower part of each passage 4 created by the piezoelectric passage substrate 22, and was prepared in the heights upper surface, and the electrode 25 prepared in the lower part, into heights, electric field parallel to the direction 26 of polarization will occur, heights 23 will deform toward the drawing upper part by the piezo-electric longitudinal mode, a pressure will occur in the ink in ink passage, and an ink drop will be breathed out. The electrode 24 on the upper surface of heights is pulled out by the end face perpendicular to the passage 4 of the passage substrate 22 by the same method as the aforementioned method, and serves as an external electrical circuit and the electrode connection 27 by which electric connection is made by the end face. Thus, this invention is applicable not only in the ink-jet recording device which used shearing mode.

[0022] The cross section which met in the direction of passage of the 5th example at drawing 9 is shown. In the 5th example, an electrode 6 is pulled out by the same end face as the field where the nozzle plate 3 of the passage substrate 1 is joined, and the electrical installation of the electrode connection 28 and a cable 13 is made on the nozzle plate side edge side. By this composition, the flexibility of cable wiring increases and the whole recording device can be miniaturized further. In addition, when the crevice between some is generated between the passage substrate 1 and a nozzle plate 3 in the portion in which the



electrode connection 29 does not exist, the seal of the adhesives for nozzle plate 3 adhesion is filled up with and carried out.

[0023] The cross section which met in the direction of passage of the 6th example at drawing 10 is shown. In the 6th example, an electrode 6 is pulled out by turns by the ends side of the end face to which the nozzle plate 3 of the passage substrate 1 is joined, and the end face of an opposite side every other passage, the electrical installation of the electrode connections 29 and 30 and a cable 13 is made on an ends side, and it connects with the external electrical circuit. If a passage pitch is conventionally set to about 100 micrometers or less, by taking this composition, the difficult electrode connection can make the pitch of an electrode connection twice a passage pitch, and can realize a high definition recording device.

[0024] The 7th example is shown in drawing 11 -14. The electrode 6 is pulled out by even the passage substrate base (a passage forming face and field of an opposite side) through the inside of the ink passage 4, and passage substrate 1 end face. That is, electrode layer 6a is formed in the passage substrate 1 in which it became from piezoelectric material and the ink passage 4 was formed all over including a base. Laser beam 9a as shown in drawing 3 (a) is irradiated aslant in a passage substrate passage side, and by using passage septum 5 the very thing as a mask, only an upper half removes electrode 6a of a passage side in general, and it leaves an electrode 6 to a lower half. Moreover, in a nozzle plate 3, the passage back end face and passage substrate base of an opposite side irradiate laser beam 9b, after protecting the required section with the metal masks 32, such as phosphor bronze, and they form the electrode connection 31 for supplying power from an external electrical circuit as shown in drawing 3 (b). In addition, complete irradiation of the aforementioned laser or mechanical polish removes electrode layer 6a of the nozzle side edge side of a passage substrate, and an ends side parallel to passage.

[0025] A cover plate 2 and a nozzle plate 3 are joined to this passage substrate 1, and the principal part of an ink-jet recording device is completed. And the manifold 12 for ink supply which has common ink room 12a in the interior is joined to a passage back end face. The cable 13 for voltage supply is connected to the last at the aforementioned electrode connection 31 in which it was prepared on the base of a passage substrate, and the ink-jet recording device of this example shown in drawing 14 is completed.

[0026] The 8th example is shown in drawing 15 and 16. The 8th example forms electrode layer 35a in the whole surface, after forming \*\*\*\* 34 which stood in a row in each passage 11 in the position which should form an electrode connection in the field in which the passage of a passage substrate was formed, the end face which makes a right angle, and a base, as shown in drawing 15 (a). And as shown in drawing 15 (b), while irradiating a laser beam 36 and forming an electrode 6 in the passage septum 5 side, the end face in which \*\*\*\* 34 was formed, and a base are ground to the grade whose \*\*\*\* 34 is not lost by the mechanical method. Only the electrode layer in \*\*\*\* 34 remains by this, and as shown in drawing 15 (c), the electrode connection 37 for supplying power to passage substrate 33 base from an external electrical circuit is formed.

[0027] The front view which looked at the 9th example from passage back to drawing 17 is shown. In the 9th example, since the passage substrate 38 which made two piezoelectric substrates 38a and 38b from which the direction of polarization differed rival is used and the deformation direction by the shearing mode of the upper and lower sides of a passage septum becomes the same, it becomes unnecessary only for a half to remove an electrode 39, and a manufacturing process can be facilitated further.

[0028] The cross section which met in the direction of passage of the 10th example at drawing 18 is shown. In the 10th example, an electrode is pulled out to the base of the passage substrate 1 via the same end face as the field where the nozzle plate 3 of the passage substrate 1 is joined, and the electrode connection 41 with an external electrical circuit is made by the nozzle plate side of passage substrate 1 base. Since the manifold 12 and the electrode connection 41 for supplying the ink which had common ink room 12a in the interior which were prepared in passage back are separable with this composition, the reliability of ink sealing of a manifold 12 and the ink-jet recording device principal part can be raised.

[0029] The cross section which met in the direction of passage of the 11th example at drawing 19 is shown. In the 11th example, it is pulled out from each electrode to a part of base [ at least ] of a passage substrate via two end faces of the passage substrate 1 by turns every other passage, and the electrode connections 42 and 43 are formed. And the electrical installation of the electrode connections 42 and 43 and a cable 13 is made on the base of the passage substrate 1. If a passage pitch is conventionally set to about 100 micrometers or less, the difficult electrode connection can make the pitch of an electrode connection twice a passage pitch by taking this composition, electrode connection is possible also for the passage pitch which is about 50 micrometers, and a high definition recording device can be realized.

[0030] The cross section which met in the direction of passage passage of the 12th example at drawing 20 is shown. In the 12th example, the drive circuit element 44 and the so-called IC are joined to passage substrate 1 base. The output section of the drive circuit element 44 is wire bonding etc., and is electrically connected with the electrode connection 43 pulled out to the base of a passage substrate via the end face of a passage substrate. The control signal and power to a drive circuit element are supplied through a cable 13 from an external electrical circuit (not shown). The number of electric wiring connected with the drive circuit element 44 from an external electrical circuit by carrying out the serial transfer of the data at an ink-jet recording device can be reduced sharply. In this example, it becomes possible to carry the drive circuit element 44, without enlarging the passage substrate 1 and the whole ink-jet recording device, in order to use the passage substrate base which was not used conventionally.

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DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

- [Drawing 1] It is the cross section which met in the direction of passage of the 1st example of this invention.
- [Drawing 2] It is the rear view which looked at the 1st example from passage back.
- [Drawing 3] It is explanatory drawing of the manufacture method of the passage substrate of the 1st example.
- [Drawing 4] It is the cross section of the whole equipment of the 1st example.
- [Drawing 5] It is explanatory drawing of the manufacture method of the passage substrate of the 2nd example.
- [Drawing 6] It is the perspective diagram of the passage back section of the important section of the 2nd example.
- [Drawing 7] It is the rear view which looked at the 3rd example from passage back.
- [Drawing 8] It is the rear view which looked at the 4th example from passage back.
- [Drawing 9] It is the cross section which met in the direction of passage of the 5th example.
- [Drawing 10] It is the cross section which met in the direction of passage of the 6th example.
- [Drawing 11] It is the cross section which met in the direction of passage of the 7th example.
- [Drawing 12] It is the rear view which looked at the 7th example from passage back.
- [Drawing 13] It is explanatory drawing of the manufacture method of the passage substrate of the 7th example.
- [Drawing 14] It is the cross section of the whole equipment of the 7th example.
- [Drawing 15] It is explanatory drawing of the manufacture method of the passage substrate of the example of the octavus.
- [Drawing 16] It is the perspective diagram of the passage back section of the important section of the example of the octavus.
- [Drawing 17] It is the rear view which looked at the 9th example from passage back.
- [Drawing 18] It is the cross section which met in the direction of passage of the 10th example.
- [Drawing 19] It is the cross section which met in the direction of passage of the 11th example.
- [Drawing 20] It is the cross section which met in the direction of passage of the 12th example.
- [Drawing 21] It is the cross section of a direction perpendicular to the passage of the conventional example.
- [Drawing 22] It is the cross section which met in the direction of passage of the conventional example.

[Description of Notations]

- 1, 14, 20, 22, 33, 38 ... Passage substrate
- 2 ... Cover plate
- 3 ... Nozzle plate
- 4 ... Ink passage
- 5 ... Passage septum
- 6, 21, 24, 25, 39 ... Electrode
- 7 ... Nozzle
- 11, 18, 27, 28, 29, 30, 31, 37, 41, 42, 43 ... Electrode connection
- 12 ... Manifold
- 12a .. Common ink room
- 15 34 ... Vadum

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[Translation done.]